ac-dc power supplies

BEHLMAN-INVAR ELECTRONICS CORP.
1723 CLOVERFIELD BLVD.
SANTA MONICA, CALIF.

REPRESENTATIVES IN ALL PRINCIPAL CITIES AND CANADA

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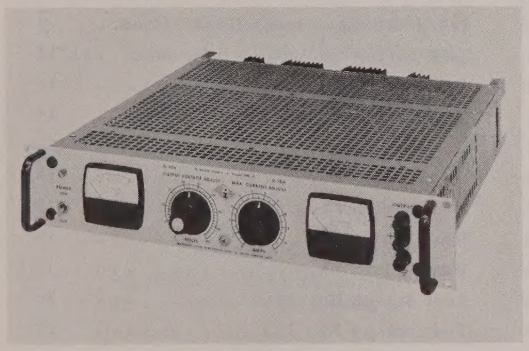
MANUAL
MODEL TPR-2.5/-5/-10 SERIES

NOTE: The information contained herein is for the sole purpose of providing the data used in operating and maintaining the above-captioned power supplies and may not be used for any other purpose or reproduced in any form, either in whole or in part, without the written consent of Behlman-Invar Electronics Corporation.

WARNING

Operation of the Behlman-Invar power supplies involves the use of high voltage. Use EXTREME CAUTION when any internal adjustments or tests are being performed.



TPR-Series 10-45 Model

CAUTION

a) ENVIRONMENTAL SPECIFICATION (See Paragraph 2) is guaranteed only when unrestricted air flow is permitted to pass through the rear transistor heatsinks. If units are stacked within any area containing high ambient temperatures, forced air must be supplied to these transistor heatsinks; otherwise DAMAGE to the unit may result.

b) Before turning the unit on, determine the type of operation desired and VERIFY that ALL EXTERNAL CONNECTIONS are properly made (see Figure 4).

c) VERIFY that OUTPUT VOLTAGE ADJUST and OUTPUT CURRENT ADJUST controls are set to the DESIRED RATING (see Paragraph 16, Operational Procedures, and Figure 4, Connection Data).

QUALITY CONTROL AND INSPECTION. Behlman-Invar Electronics Corporation functions under a company-wide quality assurance program which insures that our customer receives equipment manufactured to the most exacting standards. This quality assurance system is based on the best commercial practices augmented by policies and procedures required under MIL-Q-9858.

WARRANTY. Seller warrants the end products of its design and construction to be free from defects in material and workmanship. Any component parts other than vacuum tubes, fuses, blower motors, indicating lamps, and other indicating devices (except as warranties on these items are passed on to the seller by its suppliers) which become defective during the first year after shipment will be replaced free of charge by the seller, provided that the instrument is returned with transportation charges prepaid by the original purchaser, and that our examination discloses to our satisfaction that the instrument is defective; but if the apparatus is installed, or its installation supervised, by the seller, said year shall run from the completion of the installation, provided same is not unreasonably delayed by the buyer.

The condition of any tests shall be mutually agreed upon, and the seller shall be notified, and may be represented at, all tests that may be made. The liability of the seller to the buyer (except as to title) arising out of the supplying of the said apparatus, or its use, whether by warrant, contract, or otherwise, shall not in any case exceed the cost of correcting defects in the apparatus as herein provided, and upon the expiration of said year all such liability shall terminate.

The foregoing shall constitute the sole remedy of the buyer, and the sole liability of the seller.

PREPARATION FOR USE AND RESHIPMENT. Unpack the instrument with care and inspect it for any damage that may have occurred in transit. If there is any damage, or if the unit fails to operate properly in accordance with instructions, a claim should be filed with the carrier, with a copy of the Claim Agent's report being forwarded to Behlman-Invar Electronics Corporation. Before operating, refer to Paragraph 16, Operating Instructions.

On packaging for reshipment use adequate shock-absorbent material within the carton to prevent the instrument's corners from protruding, which would result in unit damage. DO NOT return the instrument to the factory without prior authorization from Behlman-Invar Electronics Corporation.

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1. ELECTRICAL SPECIFICATIONS.

	MODELS		
	TPR-2.5-45	TPR-5-45	TPR-10-45
OUTPUT:			
voltage (dc):	0 to 45	0 to 45	0 to 45
current (amps):	0 to 2.5	0 to 5	0 to 10
INPUT:			
voltage (ac):	105/125 or 210/250		
frequency:	47 to 1000 cps single phase		
EFFICIENCY:	50%	55%	62%
at maximum output and nominal line voltage:	approx.	approx.	approx.
REGULATION STATIC:			
for ±10% line change:	±0.0025% or 1mV max.		
for no load to full load:	0.008% or 3mV		
RIPPLE:			
rms max:	300μV	400μV	500μV
REGULATION DYNAMIC:			
recovery time no load to full load:	50 μsec. to within range of regulation		
peak amplitude of load transient:	100 mV	200 mV	300 mV
transients caused by 10 V line surge:	none	none	none
STABILITY:	±15 mV per 8 hours after warmup with line, load and temperature constant		
CONSTANT CURRENT:			
regulation, static maximum for ±10V line change:	±0.05% or ±1.2 mA	±0.05% or ±2.5 mA	±0.05% or ±5 mA
current regulation for full voltage compliance:	0.06% or 1.5 mA	0.08% or 4 mA	0.08% or 8 mA
RIPPLE:			
rms maximum:	0.03% or 0.7 mA	0.03% or 1.5 mA	0.03% or 3 mA
VOLTAGE COMPLIANCE:	0 to 45 VDC adjustable full range		
REMOTE SENSING:	Remote sense terminals are provided so that the selected output potential can be maintained across a remote load despite nominal line drop		
SHORT CIRCUIT PROTECTION:	Units are capable of being shorted continuously without damage. Turning on the unit while the output or remote load is shorted causes no damage and when the short is removed, voltage and current return to preset values.		

NOTE: All measurements must be taken at the front panel terminals with the load properly terminated to the front panel terminals.

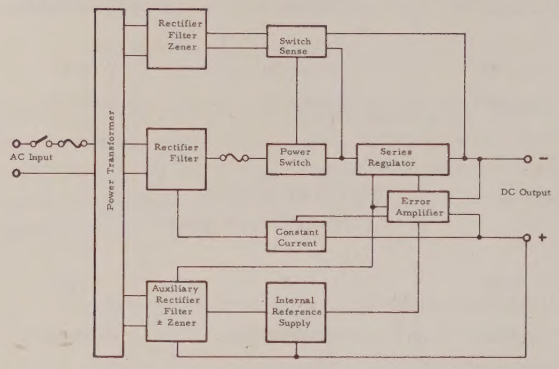
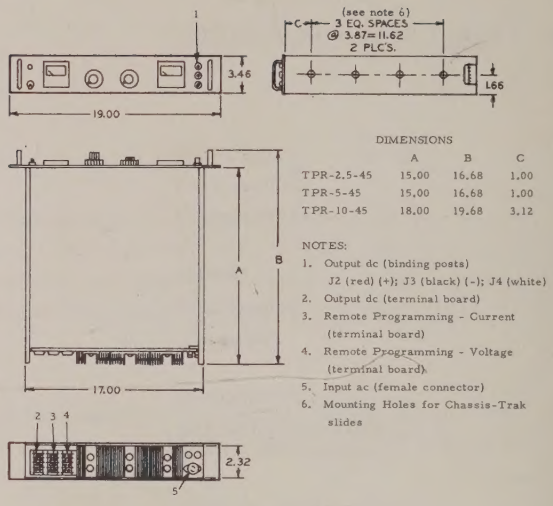


Figure 1. TPR-2.5, 5, and 10 Series Functional Block Diagram



DIMENSIONS

	A	B	C
TPR-2.5-45	15.00	16.68	1.00
TPR-5-45	15.00	16.68	1.00
TPR-10-45	18.00	19.68	3.12

NOTES:
1. Output dc (binding posts) J2 (red) (+); J3 (black) (-); J4 (white)
2. Output dc (terminal board)
3. Remote Programming - Current (terminal board)
4. Remote Programming - Voltage (terminal board)
5. Input ac (female connector)
6. Mounting Holes for Chassis-Trak slides

Figure 2. Installation Outline Drawing

2. ENVIRONMENTAL SPECIFICATIONS.

	MODELS		
	TPR-2.5-45	TPR-5-45	TPR-10-45
Maximum ambient temperature:	50° C	50° C	50° C
Temperature coefficient:		0.01% ° C or ±3 mv/° C	

NOTE: Guaranteed only when unrestricted air flow is permitted to pass through the rear transistor heatsinks. If units are stacked within any area containing high ambient temperatures, forced air must be supplied to these transistor heatsinks; otherwise DAMAGE to the unit may result.

3. MECHANICAL SPECIFICATIONS.

WEIGHT:	Approx 35#	Approx 40#	Approx 50#
DIMENSIONS:	(See Installation Outline Drawing, Figure 2)		
MOUNTING:	(See Installation Outline Drawing, Figure 2)		

4. APPLICABLE DOCUMENTS.

BEHLMAN-INVAR: Design Control Drawing # 000-0252

5. MISCELLANEOUS.

Series operation: See Figure 4, Connection Data; voltages are additive per number of units used, i.e.,

2 units 0 - 90 VDC
3 units 0 - 135 VDC

Tracking (OVP) over-voltage protection: (Optional)

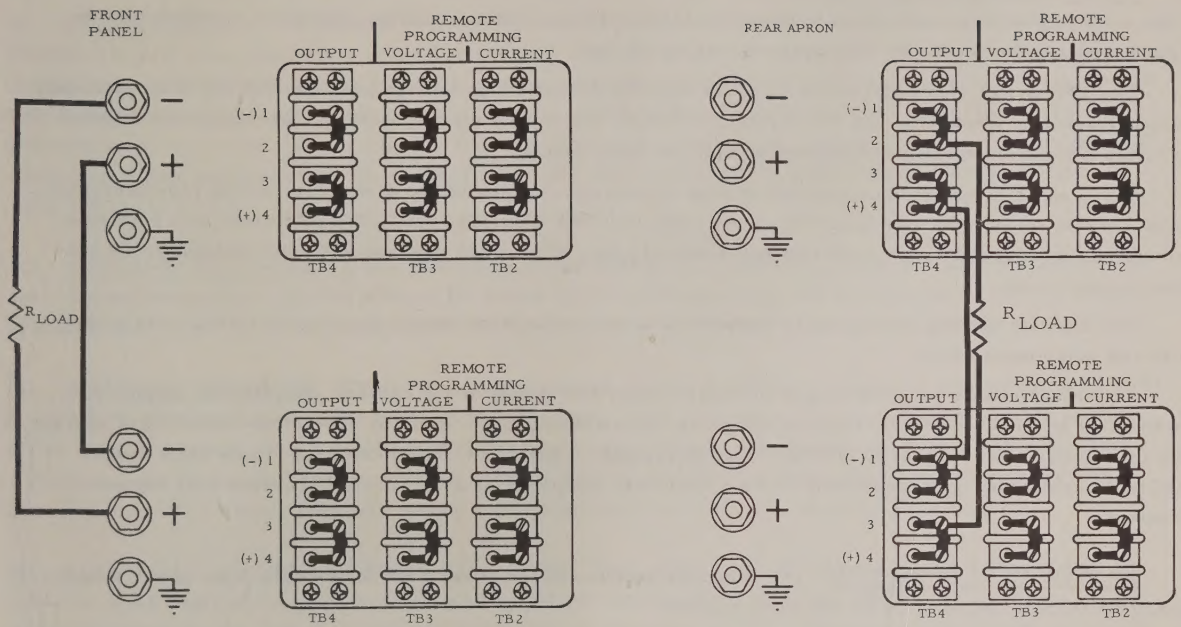


Figure 3. Series Operation Connection Data (Left 2 units, front panel connection; Right 2 units, rear apron connection)

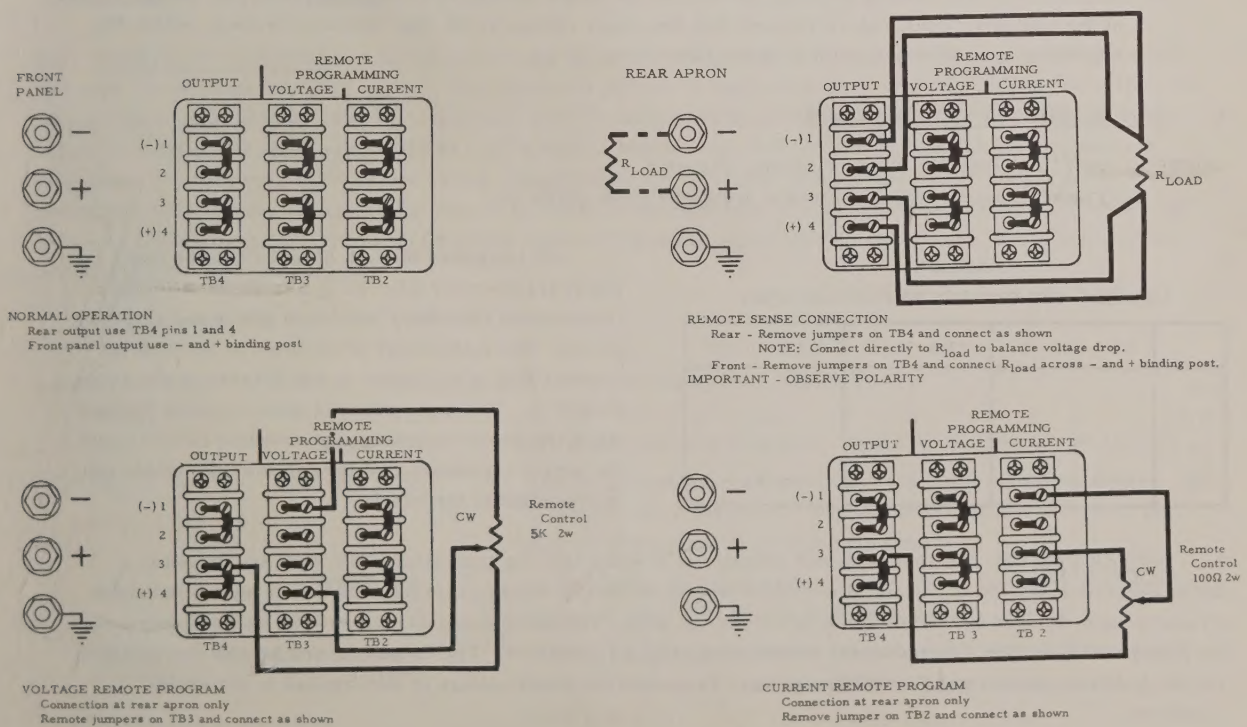

FRONT PANEL
REMOTE PROGRAMMING
OUTPUT
VOLTAGE
CURRENT
(-) 1
2
3
(+) 4
TB4
TB3
TB2
NORMAL OPERATION
Rear output use TB4 pins 1 and 4
Front panel output use – and + binding post
REAR APRON
R LOAD
REMOTE SENSE CONNECTION
Rear - Remove jumpers on TB4 and connect as shown
NOTE: Connect directly to R load to balance voltage drop.
Front - Remove jumpers on TB4 and connect R load across – and + binding post.
IMPORTANT - OBSERVE POLARITY
CW
Remote Control 5K 2w
VOLTAGE REMOTE PROGRAM
Connection at rear apron only
Remote jumpers on TB3 and connect as shown
Remote Control 100Ω 2w
CURRENT REMOTE PROGRAM
Connection at rear apron only
Remove jumper on TB2 and connect as shown

Figure 4. TPR Series, Standard Connection Data

6. INTRODUCTION AND DESCRIPTION. Behlman-Invar Electronics Corporation, who has pioneered many of the more important advancements in the field of transistorized power supplies, is pleased to submit this instruction manual for the Model TPR Series power supply unit.

The TPR series of transistorized dc power supplies provides high wattage and high stability in an extremely compact package. Measuring only 3-1/2 inches in height, these units utilize electronic pre-regulation followed by series transistor regulation to achieve exceptional performance.

These supplies operate as a constant voltage or constant current source of dc power and by pre-determined output current selection through use of the front panel OUTPUT CURRENT ADJUST will operate as a precision voltage-regulated power supply up to this pre-selected point, after which they automatically transfer to the constant current mode.

The constant current setting can be maintained at any output from zero to full current rating, over a zero to 45 volt compliance range.

Full-range remote programming is provided, either for voltage or for current. Regulation, ripple, recovery time and other electrical characteristics are exceptionally good. Entirely convection-cooled, they operate with input frequencies from 47 to 1000 cps. (See Paragraph 1, Electrical Specifications.) These units may be used in the laboratory or incorporated in other electronic equipment as a source of high quality fully regulated dc power.

7. PRINCIPLES OF OPERATION. The design parameters of the Model TPR Series solid state power supplies contribute to their operation in the following manner:

a) Provide a dc power supply fully regulated, that is variable from 0 to 45 volts dc for all three models and variable from 0 to 2.5 amps, 0 to 5 amps, and 0 to 10 amps for the respective models as specified in the Electrical Specifications (see Paragraph 1).

b) Provide a remote sensing function, permitting the output voltage to be regulated from the voltage sensed at the load end. This feature ensures that the output voltage at the load remains constant, within the regulation specifications, with a nominal line drop.

8. CIRCUIT THEORY OF OPERATION.

NOTE: a) Refer to Functional Block Diagram, Figure 1.
b) For all asterisk circuit reference designators (see Table 1).

TABLE 1
MODELS AND COMPONENT QUANTITIES

	TPR-2.5-45	TPR-5-45	TPR-10-45
Q1	1	1	3
Q15	1	2	3
C1	1	1	2
C8	1	1	2

AC is applied through S1 and F1 to the main power transformer T1. T1 is a multiple secondary transformer furnishing both main power and auxiliary power. The main power is rectified by the silicon diodes CR-1, -2, -3 and -4, and filtered by the capacitor C1*. The main power is then furnished through F2 to the power switching section which in turn feeds the series regulators that furnish the final minus polarity output of the supply.

9. POWER SWITCH. The power switch consists of series switching transistors Q1*, that are driven in a Darlington connection by Q2, which is in turn driven by the switch sensing circuit. The power switch is turned off and on upon demand by the voltage drop across the series regulator transistor Q15*. The chopped output of the power switch is then filtered by the combination of L1, L2 and C8*. The chokes L1 and L2 are clamped with silicon diodes to prevent positive voltage swing. This variable output voltage is then applied to the series regulator.

10. SWITCH SENSING. The voltage drop across the series regulators is sensed and applied to the switch sensing circuit which consists of a Schmitt trigger and a driver stage. If the voltage drop across the series regulator transistors exceeds approximately 7 volts, the power switch is turned off by the switch sensing circuit and, if the voltage across the series regulator transistors drops below approximately 4 volts, the power switch is turned on by the switch sensing circuit. Power is furnished to the switch sensing circuit by a secondary of T1 which is rectified and filtered by CR-3, CR-4, and C-2, and then regulated by the resistor R1 and the Zener diode CR-11 (12 volts).

11. AUXILIARY VOLTAGES. A plus and minus Zener regulator (82 volts) furnishes auxiliary voltages to the unit. These voltages are obtained through the output of T1 secondary being rectified and filtered by the network of diodes CR-5, -6, -7, -8 and capacitors C-3, C-4; resistors R3, R4; and Zener CR-12 and CR-13.

12. INTERNAL REFERENCE SUPPLY. A highly regulated internal reference supply of approximately 50 volts is used to furnish the reference for the main power supply. This internal reference supply is a highly stable series regulated supply using a 9 volt, 0.002%/$^{\circ}$C temperature compensated reference diode as its reference. A double balanced amplifier configuration is used for thermal stability and high gain of the series regulator. The voltage for the internal reference supply is obtained from the minus 82 volt auxiliary supply.

13. SERIES REGULATORS AND ERROR AMPLIFIER. The series regulator Q15* is driven by the power driver Q16, small signal driver Q17 and balanced amplifiers Q18 and Q19. The base of Q18 is tied across the internal reference supply through a voltage divider network composed of R47, R54 (fine voltage adjust) located on the front panel and R53 (output voltage adjust) located on the front panel. This network furnishes the output voltage reference. The base of Q19 is tied through R51 to the minus output of the supply; therefore, any error voltage between the base of Q18 (reference voltage) and the base of Q19 (output voltage), will be amplified and corrected in the series regulator.

14. CONSTANT CURRENT. A reference voltage for the constant current is established by a temperature compensated Zener diode CR-20 (9 volts). This reference voltage is applied to the base of the balanced amplifier Q8, through the voltage divider network composed of R37 (current calibrate) located on PCB #1, R48 (output current adjust) located on the front panel,and R33. Q7's base is tied through R29 to R56 which is the current sensing resistor. The collector of Q7 is tied to the voltage amplifier V6 which, in turn, is tied to the base of the driver transistor Q17. As the voltage at the base of Q7 exceeds the reference voltage established at the base of Q8, Q7 is turned on which, in turn, turns on Q6 which shuts off the small signal driver and thereby lowers the output and establishes constant current.

15. CONTROLS.

NOTE: See Figure 5, a and b, Front and Rear Panels, and Schematic, Figure 7.

a)	AC INPUT:	J1, polarized male receptacle located at the rear of the chassis.
b)	DC OUTPUT:	TB4 located on the rear panel, and J3, 4 and 5 Binding Posts located on the front panel. The output is floating and either the plus or minus may be grounded as desired.
c)	POWER ON:	S1 located on the front panel. Power ON is indicated by illumination of lamp DS1 located directly above S1.
d)	OUTPUT VOLTAGE ADJUST:	Output voltage may be varied from 0 to 45 VDC by adjustment of R53 (Coarse) outer knob and R54 (Fine) inner knob located on the front panel.

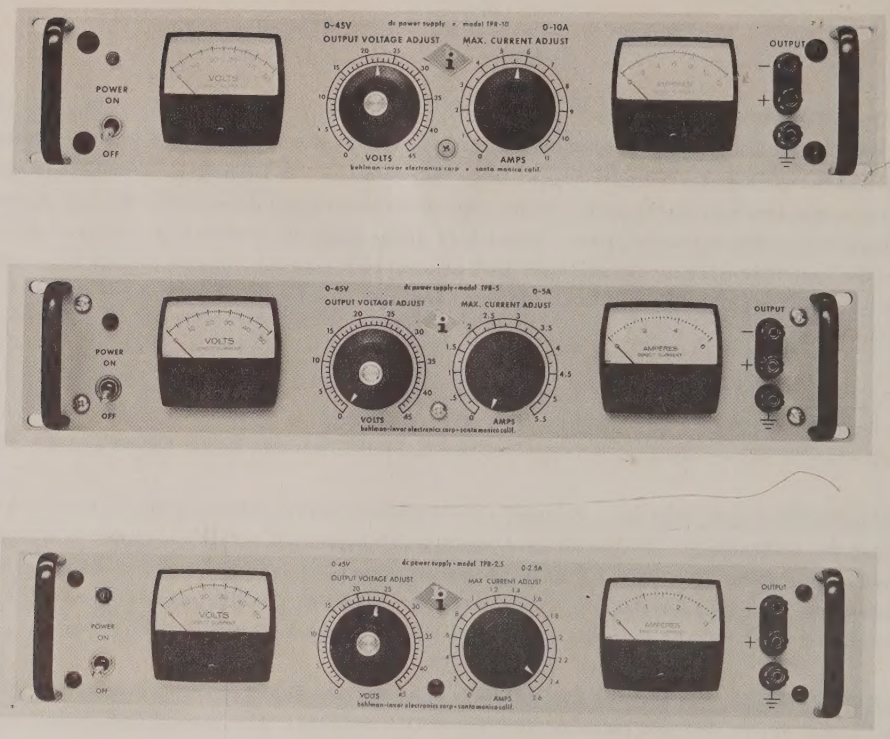


Figure 5a. Front Panels

e) OUTPUT CURRENT ADJUST: Output current may be varied from 0 to 2.5 A max., 0 to 5 A max., 0 to 10 A max. for their respective models by adjustment of R48 located on the front panel. (See Paragraph 1, Electrical Specifications.)

f) FUSES: F1, inserted in one leg of the ac input. F2, inserted in the minus leg of the raw dc section. Both fuses located on the rear panel.

16. OPERATIONAL PROCEDURES.

NOTE: See WARNING and CAUTION notes before operating unit (Title Page).

a) CONNECT: J1 to the correct ac input as listed in the Electrical Specifications. (See Paragraph 1.)

b) CONNECT: TB4 or J3, 4 and 5 Binding Posts dc output to the desired load.

c) VERIFY: That all external connections are terminated to permit desired operation.

d) POSITION: R53 - OUTPUT VOLTAGE ADJUST and R48 - OUTPUT CURRENT ADJUST to the minimum (fully counterclockwise position).

e) ACTIVATE: S1 (located on the front panel) to the ON position.

f) VERIFY: That DS1 is illuminated.

g) ADJUST: R53 - OUTPUT VOLTAGE ADJUST and R48 - OUTPUT CURRENT ADJUST to the desired operating conditions (within specification limits).

h) MONITOR: M1 ammeter and M2 voltmeter (located on the front panel) indicate the desired output operating condition current voltage respectively.

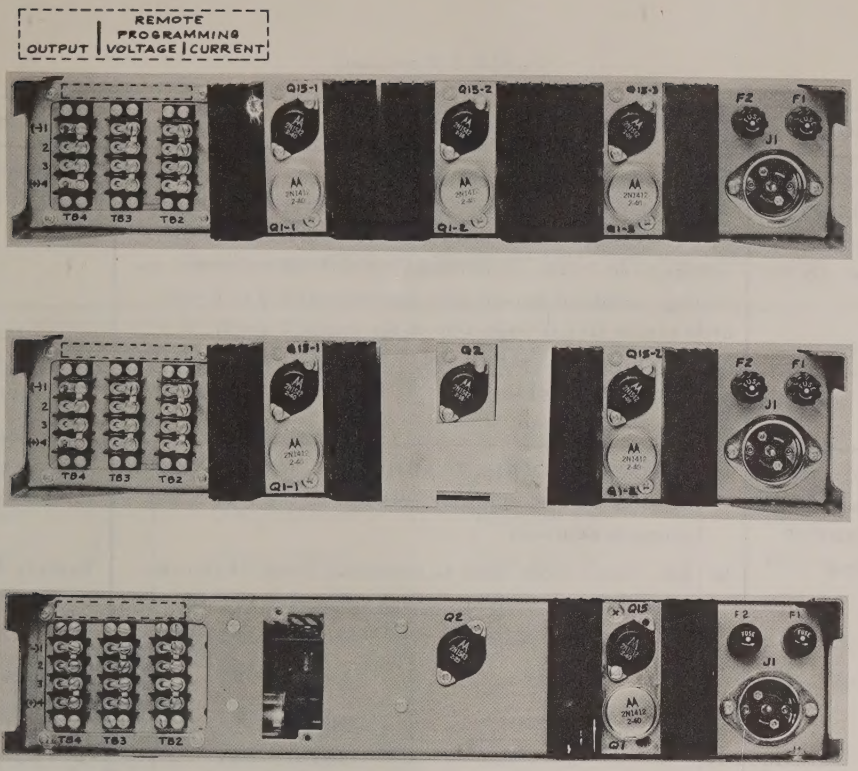


Figure 5b. Rear View

17. TROUBLE SHOOTING PROCEDURES FAULT ISOLATION.

TABLE 2
FAULT ISOLATION CHART

Trouble	Probable Cause	Remedy
#1 No Output Voltage	Defective S1	Replace S1
Blown F1	Shorted Diodes CR1 thru CR8 Shorted Capacitors C1 thru C4	Replace A/R Replace A/R
Blown F2	When DS1 is illuminated indicating dc output voltage available, NO output is caused by:	
	a) Blown F2, caused by small overload insufficient to permit the supply to operate in the constant current mode but sufficient to blow F2 after a short period of operation, i.e., the unit is fused at 10 amps; however, 10.6 amps may be pulled continuously causing F2 to blow.	Replace A/R
	b) Continuous blowing of F2 may be caused by shorted Q1 and Q15 (in the 5-45 and 10-45 series), emitter resistors must be unsoldered to check for shorted transistors.	Replace A/R
	c) Blown F2 caused by defective C8, or relay K1 not energizing with turn on of the ac power.	Replace C8, K1, or its rectifier diodes CR21, CR22 - A/R

Continued . . .

TABLE 2 (Continued)

Trouble	Probable Cause	Remedy
Control through use of OUTPUT VOLTAGE ADJUST; also Q15 seems excessively hot	NOTE: The switch sensing system will have to be tested, observing proper wave forms and test voltages (see Table 3, Test Voltage Chart) use VTVM or V. O. M. check the voltage drop, collector to emitter of Q15 under normal operating conditions should have approximately 5 to 6 volts drop across Q15 irrespective of the output E and I. If higher voltage is observed and this voltage rises and falls with the resetting of the OUTPUT VOLTAGE ADJUST, the switch sensing circuit is defective.	Repair A/R
#2 CONSTANT CURRENT will not hold to OUTPUT CURRENT ADJUST setting	a) The OUTPUT CURRENT ADJUST pot. R48 on the front panel or current calibrate pot. R37 on the PCB is not properly adjusted. b) Ref. Zener diode CR20 is defective; check CR20 voltage (should be 9 volts). Check voltages in the constant current circuitry Q6, Q7 and Q8 per test voltage chart (see Table 3).	Adjust as directed in Circuit description Replace A/R
#3 Full Output Voltage	Blown transistor Q18 or Q19.	Replace A/R
But No Voltage Control	Open voltage adjust pot. R53, R54 or open resistor R47. Shorted transistors Q1 or Q15.	Replace A/R Replace A/R
#4 No Output Voltages	Output current adjust set to zero. Blown fuses. No internal reference supply. Fine or coarse output voltage adjust pots. are defective. Constant current section of the circuitry defective.	Adjust current setting Replace A/R Repair A/R Replace A/R Repair A/R
#5 Intermittent Operation: The supply regulates for a short period under load but suddenly output voltage rises to full output with no apparent loss in regulation	Q1 and Q15 are shorted. Refer to wave forms (Figures 11 thru 14). Place Scope across Q1 collector to emitter - check wave form #1 if not identical and there seems to be no switching action in Q1.	Replace Q1 and Q15 A/R

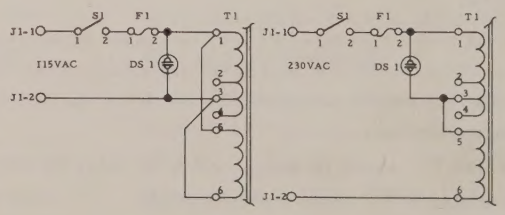


Figure 6. 115/230 Transformer Connections

TABLE 3. TPR SERIES TEST VOLTAGE CHART

NOTE: Operating Conditions — Nominal input at maximum output (voltage and current);
Readings taken with 20,000 ohms per volt meter or better;
Readings for all models should be within 10% of specified value.

Measurement Function		Desired Reading	Location
From	To		
C1 Minus	TB4-4 Output	Minus 55 vdc	Chassis
C3 Minus	TB4-4 Output	Minus 160 vdc	PCB-2
C4 Plus	TB4-4 Output	Plus 160 vdc	PCB-2
C8 Minus	TB4-4 Output	Minus 50 vdc	Chassis
C11 Plus	TB4-4 Output	Plus 1.5 vdc	PCB-1
C14 Minus	TB4-4 Output	Minus 47 vdc	PCB-1
CR-12 Minus	TB4-4 Output	Minus 82 vdc	Sub-assembly
CR-13 Plus	TB4-4 Output	Plus 82 vdc	Sub-assembly
CR-19 Minus	TB4-4 Output	Minus 9 vdc	PCB-1
CR-20 Plus	TB4-4 Output	Plus 9 vdc	PCB-1
Q1 - Collector	TB4-4 Output	Minus 54 vdc	Chassis
Q6 - Collector	TB4-4 Output	Minus 46 vdc	PCB-1
Q6 - Emitter	TB4-4 Output	Plus 5.2 vdc	PCB-1
Q7 - Collector	TB4-4 Output	Plus 8 vdc	PCB-1
Q7 - Base	TB4-4 Output	Plus 1.25 vdc	PCB-1
Q8 - Collector	TB4-4 Output	Plus 9 vdc	PCB-1
Q9 - Collector	TB4-4 Output	Minus 68 vdc	PCB-1
Q9 - Emitter	TB4-4 Output	Minus 47 vdc	PCB-1
Q10 - Base	TB4-4 Output	Minus 47 vdc	PCB-1
Q12 - Collector	TB4-4 Output	Minus 41 vdc	PCB-1
Q13 - Collector	TB4-4 Output	Minus 28 vdc	PCB-1
Q14 - Collector	TB4-4 Output	Minus 28 vdc	PCB-1
Q14 - Base	TB4-4 Output	Minus 9 vdc	PCB-1
Q15 - Collector	TB4-4 Output	Minus 50 vdc	PCB-1
Q15 - Emitter	TB4-4 Output	Minus 45 vdc	PCB-1
Q18 - Base	TB4-4 Output	Minus 45 vdc	PCB-1
Q19 - Base	TB4-4 Output	Minus 45 vdc	PCB-1
Q19 - Collector	TB4-4 Output	Minus 46 vdc	PCB-1
	FLOATING		
CR2	Across	19 vdc	PCB-2
CR11	Across	12 vdc	PCB-1

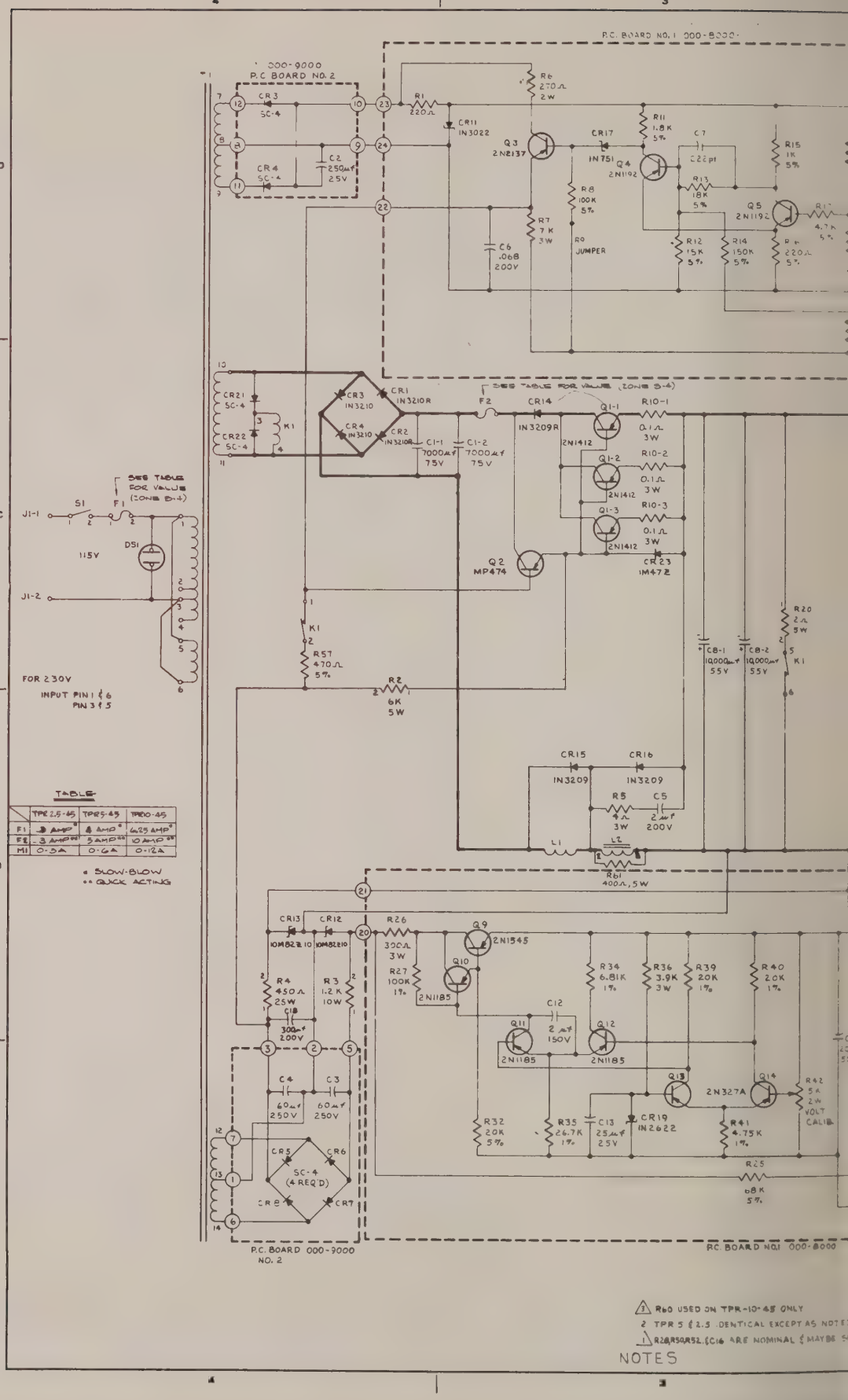
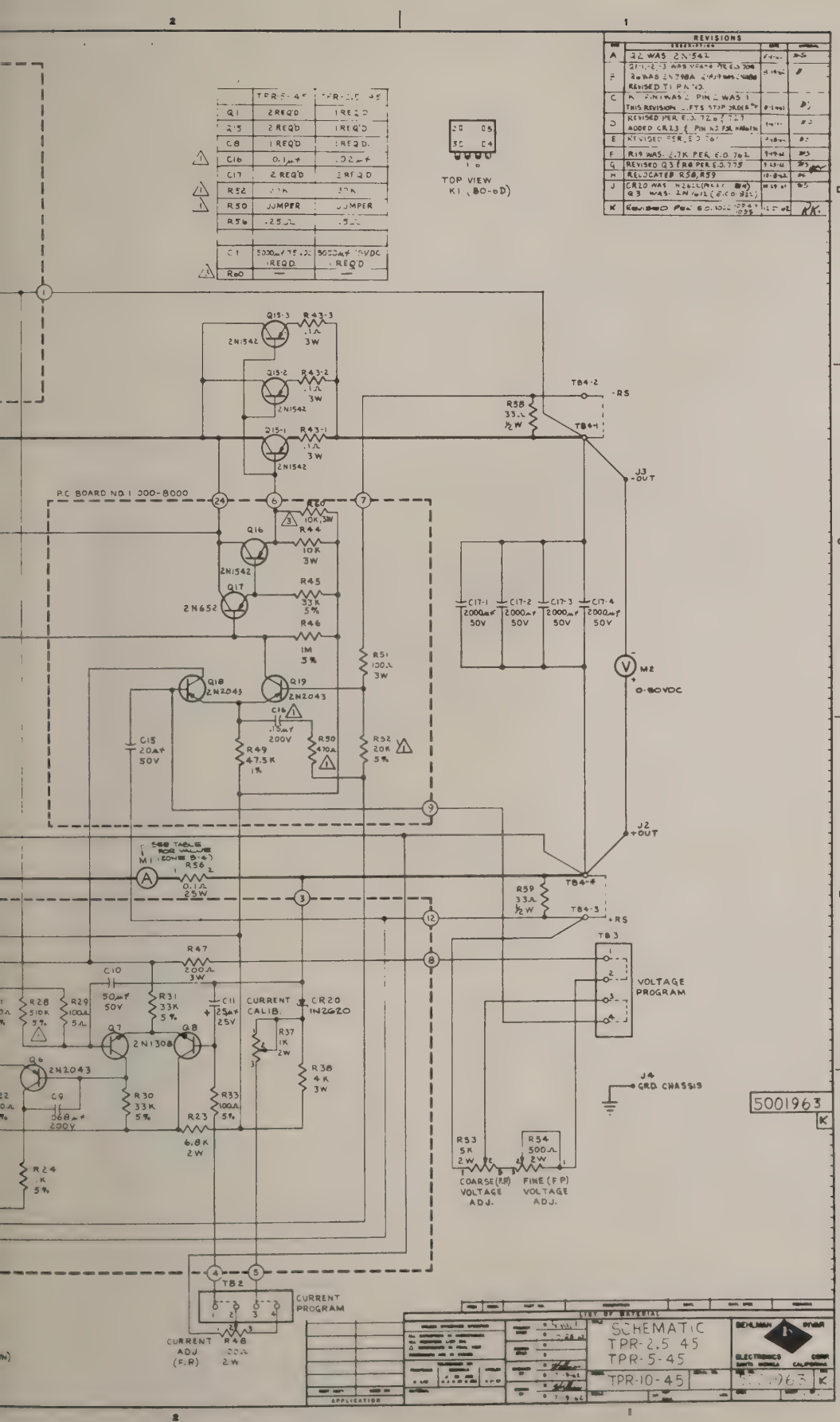


Figure 7. TPR Se



osite Schematic

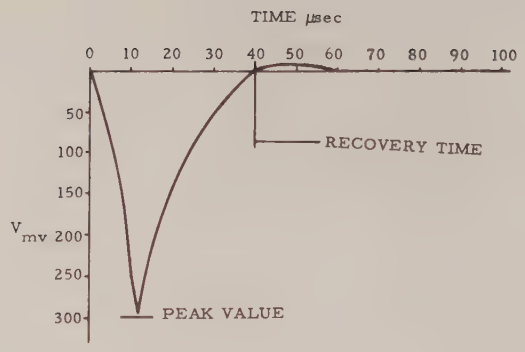


Figure 8. Graph, Transient Response Time

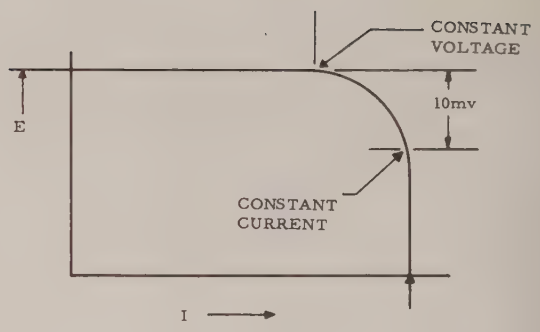


Figure 9. Graph, Transfer Curve From Voltage to Current Regulation

TABLE 4
TEST EQUIPMENT REQUIRED

Item	Nomenclature	Model or Equivalent	Function
1	Variac	0 to 130 VAC/780 VA - W5	Control ac line input
2	AC Voltmeter	0 to 130 VAC	Verify ac line input
3	Differential dc voltmeter (DDCV)	John Fluke #801	Verify dc voltages A/R
4	RMS Voltmeter	Ballantine #302	Verify true rms dc ripple
5	Portable continuity meter (V. O. M.)	Triplett 630 NA	Verify resistances, open or shorted conditions, miscellaneous dc and ac voltages A/R
6	Scope	Tektronix #502 with 1 mV sensitivity. Dual Beam/Trace	Verify wave forms A/R
7	Variable output load	15 ohm, 10 amp, wire-wound Rheostat	Provide variable loads for the TPR-5-45 and 10-45 A/R
8	Variable output load	50 ohm, 3 amp, wire-wound Rheostat	Provide variable loads for the TPR-2.5-45 A/R
9	Mercury switch	Durakool (10 amps) or house type mercury switch	Used for transients and load test evaluation
10	Decade box	Ohmite 1 ohm to 1 megohm	Circuit evaluation for substitution of correct resistance

18. CHASSIS GROUND CHECK. Verify the dc resistance with V. O. M. between the following points:

From	To	Should Read
Ground Terminal	Chassis	0
Plus Output	Chassis	20 megohms
Minus Output	Chassis	20 megohms
AC Line Input Terminals	Chassis	20 megohms

NOTE: Any deviation in the above readings would require FAULT ISOLATION before power is applied.

19. ELECTRICAL CIRCUIT CHECK OF POWER SUPPLY. Preliminary setup of load and power supply follows.

Use Test Set-up No. 1

a)	ACTIVATE:	the load mercury switch to the "OFF" position.
b)	ADJUST:	the ac line Variac to the zero output position.
c)	ADJUST:	the OUTPUT VOLTAGE R54 coarse and R53 fine to the maximum clockwise position.
d)	ACTIVATE:	the "ON-OFF" switch on the ac Variac to the "ON" position.
e)	ADJUST:	the ac Variac slowly from 0 to 115 VAC. 1) The dc output of the power supply as read on the DDCV should be the specified voltage for the particular supply and this voltage should be regulated on VTVM scale of DDCV. 2) CHECK with a voltmeter that no voltage exists from the power supply chassis to the power supply negative output terminal.
f)	ACTIVATE:	the load mercury switch to the "ON" position. A reading of current should be visible on the ammeter.
g)	ADJUST:	the load so that the ammeter reading is as specified for the power supply.

20. TEST PROCEDURE FOR VERIFYING PROPER OPERATION.

Use Test Set-up No. 1

a)	CONNECT:	Variac to the ac input.
b)	CONNECT:	AC voltmeter across the line input.
c)	CONNECT:	load to mercury switch, switch in "OFF" position.
d)	CONNECT:	scope across Q1 and Q10 using the emitter of Q1 as common for the two scope inputs.
e)	CONNECT:	V. O. M. #1 across Q15, set to 12V scale.
f)	CONNECT:	V. O. M. #2 across C8, set to 300V scale.
g)	ADJUST:	OUTPUT VOLTAGE ADJUST (coarse) to 45 VDC.
h)	ADJUST:	OUTPUT VOLTAGE ADJUST (fine) to maximum clockwise or calibrate position.
i)	ADJUST:	OUTPUT CURRENT ADJUST to maximum clockwise position.
j)	ACTIVATE:	S1 to the "ON" position.
k)	ADJUST:	Variac control slowly to approximately 80 VAC output.
l)	MONITOR:	aurally and visually so that at 80 VAC input the relay K1 "engages" to operating condition and that output dc voltage is indicated on meter M1 on the TPR.
m)	INCREASE:	Variac ac control adjustment slowly to 115 VAC output of the Variac.
n)	MONITOR:	Visually so that the dc output of the TPR indicates approximately 45V with 115 VAC nominal line input.

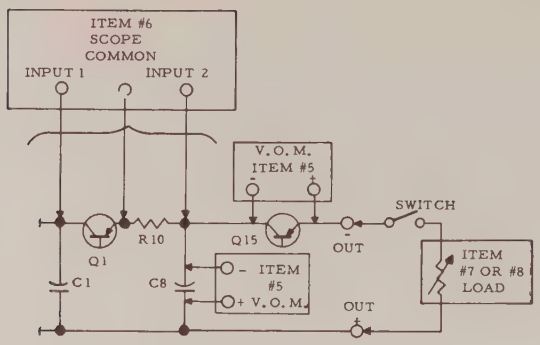


Figure 10. Test Set Up No. 1

WARNING

Safety and caution should be observed if it becomes necessary to make the following adjustment, (see Step o), the shaft of R42 (output voltage adjust calibrate pot.) is at PLUS OUTPUT POTENTIAL and should NOT be grounded to the chassis or any output terminal.

o)	ADJUST:	(Only if the dc output stops short of, or exceeds, 45 volts) R42 output voltage calibrate pot. (located on the PCB) to provide a precise 45 VDC output of the TPR unit.
p)	MONITOR:	Voltmeter across Q15 for a slow pulsating voltage of approximately 4 volts.
q)	MONITOR:	That scope wave form of Q1 presents a switching action (see Fig.11).
r)	ADJUST:	Load to minimum.
s)	ADJUST:	OUTPUT CURRENT ADJUST to 1/2 the rated current for the model being tested, i.e., 5 amps for the TPR-10-45.
t)	INCREASE:	Load until it is visually verified that the supply is operating in the CONSTANT CURRENT mode and/or that 1/2 of the max. current output is exceeded, i.e., 6 amps for the TPR-10-45 unit.
u)	ADJUST:	R37, current calibrate pot. (located on the PCB) to the rating as marked on the front panel setting of the OUTPUT CURRENT ADJUST pot., verify on M1.
v)	ADJUST:	OUTPUT CURRENT ADJUST pot. to the rated current output of the model being tested, i.e., 10 amps for TPR-10-45 unit.
w)	INCREASE:	Load to maximum.
x)	VERIFY:	M1 reading that current stops rising at rating indicated by OUTPUT CURRENT ADJUST pot.

21. WAVE FORM MEASUREMENT OF PRE-REGULATOR SECTION.

Use Test Set-up No. 1

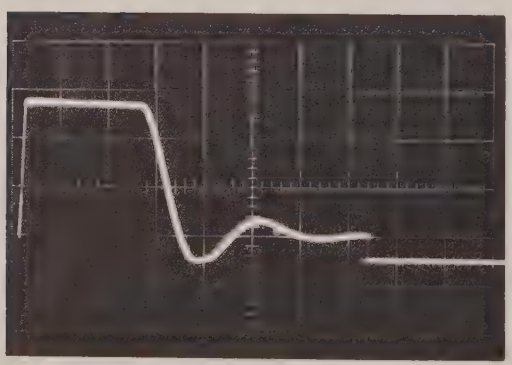


Figure 11. Wave Form #1 - Volts Collector to Emitter Vce of Q1, 20v/div., 500 μsec'/cm at 115 vac, 45 vdc, max. I

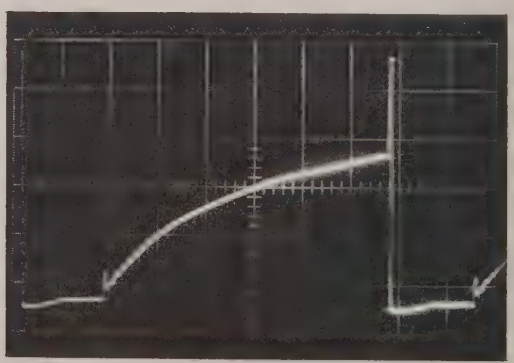


Figure 12. Wave Form #2 - Emitter I, Ic of Q1, 0.5A/div., 2 millisec'/cm at 45 vdc, max. I

PRE-REGULATOR SECTION TEST STEP PROCEDURE.

a)	ADJUST:	OUTPUT VOLTAGE ADJUST pot. to 45 VDC.
b)	INSERT:	10 amp load to the power supply.
c)	VERIFY:	OUTPUT CURRENT ADJUST is set to the maximum clockwise position.
d)	MONITOR:	Scope wave forms for comparison to Figures 11 and 12 above.
e)	ADJUST:	OUTPUT VOLTAGE ADJUST to 10V output and load to full rated load.
f)	MONITOR:	Scope wave forms for comparison to Figures 13 and 14 below.

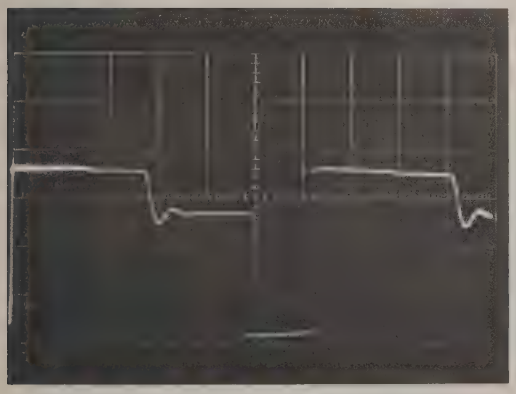


Figure 13. Wave Form #3 - Volts Collector to Emitter Vce of Q1, 20v/div., 2 millisec'/cm at 115 vac, 10 vdc, max. I

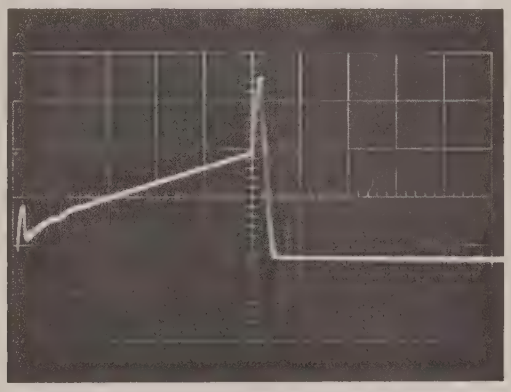


Figure 14. Wave Form #4 - Emitter I, Ic of Q1, 1A/div., 500 μsec'/cm at 10 vdc, max. I

23. LINE AND LOAD REGULATION.

Use Test Set-up No. 2

When measuring regulation, verify that the voltmeter used is connected directly to the output terminals of the power supply; primary consideration being that the voltmeter be connected at the power supply terminals, not at the load nor through banana plugs connected to the power supply output. With heavy output current flow, very minute contact resistance is sufficient to allow a high millivolt drop, preventing accurate measurement, i.e., If the supply is delivering 10 amps, a contact resistance of only one milliohm (0.001 ohm) will result in a voltage drop of 10 millivolts. Specification guarantees a load regulation of 3 millivolts maximum; hence, incorrect connections allowing a high contact resistance would present an untrue regulation measurement that did not conform to specifications. The TPR series regulation is so excellent that the test equipment and procedures used to check it must be equal in quality and correct in test set-up. The recommended test equipment is advised for use in basic regulation measurements.

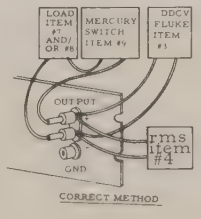


Figure 15. Test Set-up No. 2

LINE ADJUST STEP PROCEDURE

a)	ADJUST:	the load mercury switch to the "OFF" position.
b)	ADJUST:	the ac line input variac to the zero output position.

c)	ADJUST:	the OUTPUT VOLTAGE ADJUST R54 to the maximum clockwise position.
d)	ACTIVATE:	the "ON-OFF" switch on theac variac to the "ON" position.
e)	ADJUST:	the ac variac slowly from 0 to 115 VAC input.
	MONITOR:	the dc output of the power supply as read on the DDCV* should be approximately 45 volts and this voltage should be regulated on VTVM scale of DDCV.
	VERIFY:	with a V. O. M. that no voltage exists from the power supply chassis to the power supply negative output terminal.
f)	ACTIVATE:	the load mercury switch to the "ON" position. A reading of current should be visible on the ammeter M1.
g)	ADJUST:	variable load so that the ammeter reading M1 is as specified for the power supply.

24. LINE REG. STEP PROCEDURE.

a)	ADJUST:	the DDCV "NULL" switch to the required scale within the specified limits.
b)	NULL:	the DDCV to the power supply output.
c)	ADJUST:	the ac variac through the specified voltages, within the specified limits.
d)	MONITOR:	the amount of deviation from zero on the DDCV. The line regulation should not be read as the initial surge. The line regulation should be read at the point where the DDCV pointer comes to rest. The deviation should be within the specifications for line regulation under full load conditions.
e)	ACTIVATE:	the load mercury switch to the "OFF" position.
f)	VERIFY:	the line regulation under the no-load condition, per paragraph 24(a) through(d) above. The deviation should be within the specifications for line regulation under no load conditions.

25. LINE AND LOAD REGULATION (STATIC).

STATIC LOAD REGULATION STEP PROCEDURE

a)	ADJUST:	the ac line voltage variac to the minimum line voltage listed in the specifications.
b)	ADJUST:	the DDCV "NULL" switch to the required scale within the limits of the specifications.
c)	NULL:	the DDCV to the power output.
d)	ACTIVATE:	the load mercury switch to the "ON" position.
e)	MONITOR:	the amount of deviation from zero on the DDCV. The static load regulation should not be read at the point where the DDCV pointer comes to rest. The deviation should be within the specifications for load regulation under low ac line conditions.

*DDCV hereinafter referred to equals differential DC voltmeter John Fluke Model 801.

f) ADJUST: the ac line voltage variac to maximum line voltage as listed in the specifications.

g) MONITOR: the static load regulation under the high line condition. (See paragraph 24(b) through (e).)

26. RIPPLE.

RIPPLE STEP PROCEDURE

a) ADJUST: the ac line voltage variac to the minimum line voltage listed in the specifications.

b) ACTIVATE: the load mercury switch to the "ON" position. ADJUST THE LOAD for maximum current reading on the ammeter within the limits of the specifications.

c) DISCONNECT: the DDCV leads from the positive and the negative output terminals on the power supply.

d) CONNECT: the positive and negative leads from the rms voltmeter to the respective output terminals of the power supply.

e) ADJUST: the rms voltmeter to the required scale.

f) MONITOR: the amount of ripple on the rms voltmeter.

NOTE: To read peak-to-peak ripple, perform the same procedure, (d) through (f) outlined above, substituting the oscilloscope for the rms meter.

27. DYNAMIC REGULATION.

DYNAMIC REGULATION TEST STEP PROCEDURE

a) ADJUST: the ac line variac to the nominal voltage as listed in the specifications.

b) CONNECT: the positive and negative leads from the oscilloscope to the positive and negative output terminals of the power supply, respectively.

c) ADJUST: the oscilloscope to an approximate setting as follows:

1) SET: the sweep to 50 microseconds per centimeter.

2) SET: the vertical gain to 50 mV per centimeter.

d) ADJUST: the oscilloscope triggering level at the center line of the oscilloscope scale.

e) ADJUST: the scope sweep so that the ac amplitude of the power supply output under no-load conditions is read on the top line of the oscilloscope scale.

f) SET: the triggering mode control on the oscilloscope to the internal negative position.

NOTE: If STATIC load regulation does not meet specifications per paragraph 1, a slight adjustment of R52 (20 K ohms nominal) may be necessary to bring the STATIC load regulation into specifications.

28. CONSTANT CURRENT.

CONSTANT CURRENT TEST STEP PROCEDURE

Use Test Set-up No. 3

a)	ADJUST:	OUTPUT VOLTAGE ADJUST to 45 VDC.
b)	ADJUST:	OUTPUT CURRENT ADJUST to maximum current allowable for the model being tested.
c)	INCREASE:	the load to the point (d) of next step.
d)	MONITOR:	the output voltmeter to verify the VOLTAGE output starts to drop.
e)	ADJUST:	the Fluke meter on the 0.01 scale for NULL across R*.
f)	INCREASE:	the load to short circuit.
g)	VERIFY:	the difference voltage on the Fluke meter.

NOTE: The difference voltage should not exceed the specifications of the model being tested. IF RESULT DOES NOT meet specifications, perform step (h).

h)	TRIM:	R28 until step (g) is within specification.

29. CURRENT RIPPLE.

CURRENT RIPPLE TEST STEP PROCEDURE

a)	REPLACE:	the Fluke meter as indicated in Test Set-up No. 3 (see Figure 16) with the BALLANTINE METER.
b)	REPEAT:	all preceding step procedures listed above steps a through h).

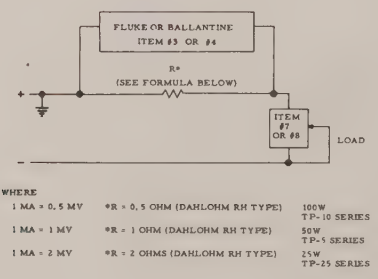


Figure 16. Test Set up No. 3.

ADDENDA SHEET

For

DC Power Supply

Model TPR-2.5/-5/-10 Series

Pub. No. 99011 Manual, Dated: December, 1962 May, 1963

TPR Series Parts List and Schematic Rev.

Ref. Desig.	Was	Is	Remarks
C 7	222 pf	100 pf	
C 9	Deleted		
C 10	50 mf, 50V	.033 mf, 200V	
C 18	Added	.05 mf, 200V	E of Q7 to Pin 2 of PCB
C 19	Added	.033 mf, 200V	Paralleled to R 6
CR 20	1N2620	1M10Z5	
R 2	6K, 5W	6K, 10W	
R 6	270 Ohm, 2W	200 Ohm, 5W	
R 12	15K	7.5K, 1/2 W	
R 13	18K	9.1K, 1/2 W	
R 15	1K	680 Ohm, 1/2 W	
R 16	220 Ohm	110 Ohm, 1/2 W	
R 61	Added	100K (Nom.) 1/2 W	B of Q7 to Pin 21 of PCB
R 62	Added	100 Ohm, 1/2 W	E to B of Q2
Q 2	MP474	B 11412	
		Parts Peculiar Section TPR 2.5-45	
F 1	3 Amp	5 Amp	313005
		Parts Peculiar Section TPR 5-45	
F 1	4 Amp	6-1/4 Amp	3136.25
		Parts Peculiar Section TPR 10-45	
F 1	6-1/4 Amp	10 Amp	311010
C 16	0.15 mf	0.033 mf	Aerovox P123ZN
R 50	470 Ohm	200 Ohm	

Page 19, Para. 28, add step i below:

i) In constant current mode with max. output current, vary the line voltage from 105 to 125 volts. Adjust the value of R 61 (100K nominal) until unit operates within specifications.

NOTE: All F1 values to be one-half indicated values for 230 VAC operation.

Qty/Ref.	Description	Mfg. Part No.	Manufacturer
R42	Pot. 5K, 2W, WW	A43-5000	Clarostat
R44, 55	Resistor, 10K, 3W	4454	Ohmite
R46	Resistor, 1 Meg.	_	Allen-Bradley
R47	Resistor, 200 ohm, 3W	4399	Ohmite
R48	Pot. 100 ohm, 2W	RA20NAS010A/252	Clarostat
R51	Resistor, 100 ohm, 3W	4392	Ohmite
R53, 54	Pot. (Dual) 5K, 500 ohm, 2W	CTS34612	Chicago Tel. Supply
R57	Resistor, 470 ohm	-	Allen-Bradley
R58, 59	Resistor, 33 ohm	-	" "
R61	Resistor, 400 ohm, 5W	1524	Ohmite
C2	Cap. Lytic, 250/25 Vdc	BR-250-25	Cornell-Dubilier
C3, 4	Cap. Lytic, 60/250 Vdc	BR-60-250	" "
C5	Cap. Mylar, 2/200 Vdc	ZD2A205	Elpac
C6, 9	Cap. Mylar, 0.068.200 Vdc	MMW68325	Texas Research
C7	Cap. Mica, 220PFD/500 Vdc	CM-15-E-221	Arco
C8-1	Cap. Lytic, 10,000/55 Vdc	NV55M100	Westcap
C10	Cap. Lytic, 50/50 Vdc	NLW-50-50	Cornell-Dubilier
C11, 13	Cap. Lytic, 25/25 Vdc	NLW-25-25	" "
C12	Cap. Mylar, 2/150 Vdc	NLW-2-150	" "
C14, 15	Cap. Lytic, 20/50 Vdc	NLW-20-50	" "
C17-1, 2	Cap. Lytic, 2000/50 Vdc	NV50P20	Westcap
C18	Cap. Lytic, 300/200 Vdc	NV200H3	"
CR3, 4, 5, 6, 7, 8, 21, 22	Diode, Rectifier	SC4	Semtech
CR11	Diode, Zener	IN3022	Motorola
CR12, 13	Diode, Zener	10M82Z10	"
CR14	Diode, Rectifier	IN3209R	"
CR15, 16	Diode, Rectifier	IN3209	"
CR17	Diode, Zener	IN751	"
CR19	Diode, Zener	IN2622	"
CR20	Diode, Zener	IN2620	"
CR23	Diode, Zener	IM47	"
Q1	Transistor,	2N1412	"
Q2	Transistor, Power	MP474/2N1543	"
Q3	Transistor	2N2137	"
Q4, 5	Transistor	2N1192	"
Q7, 8	Transistor	2N1308	Texas Instrument
Q9	Transistor	2N1545	Motorola
Q10, 11, 12	Transistor	2N1185	"
Q13, 14	Transistor	2N327A	Raytheon
Q15, 16	Transistor	2N1542	Motorola
Q17	Transistor	2N652	"
Q6, 18, 19	Transistor	2N2043	"

"Parts Peculiar" to the TPR-2.5-45 Model Only

Qty/Ref.	Description	Mfg. Part No.	Manufacturer
1	Assembly, Rear	4002299	Behlman-Invar
1	Assembly, PCB #1	4002328-2	" "
1	Assembly, Rectifier Plate	3002033	" "
T1	Transformer	011-0050	" "
L1	Choke	011-0051	" "
L2	Choke	011-0052	" "
M1	Ammeter, 0-3Amp	1500009	Dale Products
F1	Fuse, 3 Amp. Slo-Blo	313003	Littlefuse
F2	Fuse, 3 Amp.	312003	"
C1	Cap. Lytic, 5000/75 Vdc	NV75C50	Westcap
C16	Cap. Mylar, 0.02/200 Vdc	P83Z	Aerovox
R52	Resistor, 30K (nominal)		Allen-Bradley
R56	Resistor, 0.5 ohm 25W, WW, 3%	RH 25/Equal	Cal. Resistor

"Parts Peculiar" to the TPR- 5-45 Model Only

1	Assembly, Rear	4002300	Behlman-Invar
1	Assembly, PCB #1	4002328-5	" "
1	Assembly, Rectifier Plate	3002033	" "
T1	Transformer	012-0050	" "
L1	Choke	012-0051	" "
L2	Choke	012-0052	" "
M1	Ammeter, 0-6 Amp.	1500010	Behlman-Invar
F1	Fuse, 4 Amp. Slo Blo	313004	Littlefuse
F2	Fuse, 5 Amp.	312005	"
R10-1, 2, R43-1, 2	Resistor, 0.1 ohm, 3W	000-0296	Behlman-Invar
R52	Resistor, 30K (nominal)		Allen-Bradley
R56	Resistor, 0.25 ohm, 25W, 3%	RH 25/Equal	Cal. Resistor
C1	Cap. Lytic, 5000/75 Vdc	MV75C50	Westcap
C16	Cap. Mylar, 0.1/200 Vdc	MMW10425	Texas Research
Q1-1, 2	Transistor	2N1412	Motorola
Q15-1, 2	Transistor	2N1542	"

"Parts Peculiar" to the TPR-10-45 Model Only

1	Assembly, Rear	4002301	Behlman-Invar
1	Assembly, PCB #1	4002328-10	" "
1	Assembly, Rectifier Stack	4001961	" "
T1	Transformer	013-0050	" "
L1	Choke	013-0051	" "
L2	Choke	013-0052A	" "
M1	Ammeter, 0-12 Amp.	1500011	Behlman-Invar
F1	Fuse, 6-1/4 Amp.	3136.25	Littlefuse
F2	Fuse, 10 Amp.	311010	"
R10-1, 2, 3 R43-1, 2, 3	Resistor, 0.1 ohm, 3W	000-0296	Behlman-Invar
R50	Resistor, 470 ohm (nominal)		Allen-Bradley
R52	Resistor, 20K (nominal)		" "

"Parts Peculiar" to the TPR-10-45 Model Only (Continued)

Qty/Ref.	Description	Mfg. Part No.	Manufacturer
R56	Resistor, 0.1 ohm, 25W	RH 25/Equal	Dale Products
R60	Resistor, 10K, 3W	4452	Ohmite
C1-1, 2	Cap. Lytic, 7000/75 Vdc	NV75M70	Westcap
C8-2	Cap. Lytic, 10,000/55 Vdc	NV55M100	"
C16	Cap. Mylar, 0.15/200 Vdc	MMW15425	Texas Research
C17-3, 4	Cap. Lytic, 2000/50 Vdc	NV50P20	Westcap
CR1, 2	Diode, Rectifier	1N3210R	Motorola
CR3, 4	Diode, Rectifier	1N3210	"
Q1-1, 2, 3	Transistor	2N1412	"
Q15, 1, 2, 3	Transistor	2N1542	"